OVERALL PROGRAMMES AT THE UNIVERSITY OF SURREY

By M.J.M. Meerman

Abstract

The UoSAT Spacecraft Engineering Research Unit at the University of Surrey has over the last 12 years built, launched and operated in space 7 satellites, a further 2 are ready for launch in Kourou, French Guyana, and yet another is being integrated at Surrey for launch in 1994.

These satellites have been built on a small budget, typically around 1.5 million US$, and in a very short time, around 1 year from begin of design to launch.

They have been built for a variety of customers, ranging from the French space agency CNES, to US third world aid organisation Satellife.

In 1985 the University founded Surrey Satellite Technology Limited, a wholly owned university company, to act as interface between the University and industry, with the aim to promote transfer of academic knowledge to industry, and to generate research funding in return.

The satellites experience is offered to customers in a variety of packages, from a straightforward build and delivery by UoSAT, to a complete package including training for engineers, technology transfer and ground stations.

Introduction

The UoSAT programme started at the University of Surrey in 1979, with the design and construction of UoSAT-1, a 65 kg satellite launched by NASA, in 1981. The aims of the programme were to develop and investigate cost effective spacecraft engineering techniques, to promote space education, to demonstrate the capabilities of microsatellites, and to develop industrial exploitation of microsatellites.

In 1984 a second launch opportunity came up, again with NASA. A new satellite, UoSAT-2, was designed, built and launched within the six months available.

The satellites support a number of experiments: radiation effects measurements, CCD remote sensing, computer and related micro electronics technology, general spacecraft engineering techniques, software development for advanced autonomous spacecraft control and communication.

A New Launcher

UoSAT-1 and 2 had been launched by NASA as a secondary payload, utilising spare capacity on two Delta rockets. For these launches two special brackets were made up to mount the satellites to the rocket structure. These designs were one-offs, meaning that every satellite would have to comply with a new and modified set of requirements, influencing mass, envelope, structural stiffness and a variety of others, operational and technical.

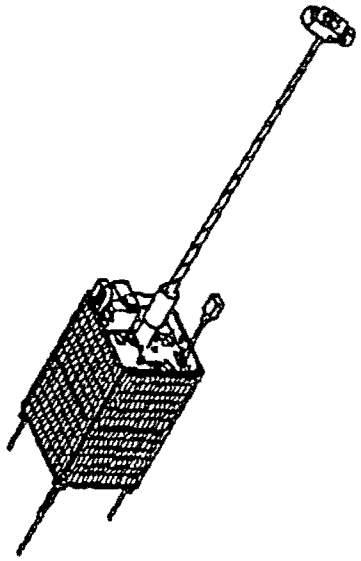
For a sustained development of satellites, and for a longer term basis on which to invest, this was not a suitable situation. A search was made for alternative launchers with the ability to launch microsatellites, between 10 and 100 kg.

In 1988 Arianespace developed a dedicated structure for their Ariane 4 launcher, which would fulfil this requirement. The Ariane Structure for Auxiliary Payloads (ASAP) is a ring, mounted on the top of the third stage of the rocket, on which a number of microsatellites can be mounted.

The maximum mass of the satellites is currently 50 kg, and the maximum available envelope is 356*356*670 mm.

The interface is kept as simple as possible, with the ring having a flat surface into which a suitable number of mounting inserts can be placed, to whatever layout is needed. The electrical interface is also kept to a minimum, with only a battery trickle charge line, pyrotechnic separation command lines, and a separation confirmation signal provided for. The satellites are typically launched in switched off state, and they switch on at separation from the rocket, using a simple mechanical switch.

There has been, on average, one ASAP launch per year into low Earth orbit since the first ASAP in 1990, carrying between 2 and 6 satellites on each.



PoSAT microsatellite in-orbit configuration

The UoSAT Satellites

The following satellites have been built, launched and operated by the University of Surrey and SSTL:

Satellite	*Payloads*
UoSAT-1, 1991, NASA	CCD Imager, Radiation detectors (Geiger counters), HF beacons, Technology demonstration (Micro-electronics), Educational experiments
UoSAT-2, 1994, NASA	Particle-Wave analyser experiment, Store-and-Forward communications, CCD imager, Educational experiments Microcomputer technology and Attitude control demonstrations
UoSAT-3, 1990 Ariane	Cosmic particle experiment, Store-and-Forward communications, VLSI and autonomous attitude control technology demonstration
UoSAT-4, 1990, Ariane	CCD and Transputer Earth imaging experiment, Solar cell and Attitude sensor technology experiments
UoSAT-5, 1991, Ariane	Store-and-Forward communications, Solar Cell experiment, CCD Imager Transputer technology experiment,
S80/T, 1992, Ariane	VHF communication demonstration payload, for CNES, via Matra, France
KITSAT-1, 1992, Ariane	Store-and-Forward communications, Cosmic particle experiment, Earth imaging system, Digital Signal Processing Experiment, Technology transfer for KAIST, Korea

The following satellites are awaiting launch:

Healthsat-2, 1993, Ariane	Store-and-Forward communications, for Satellife, USA
PoSAT-1, 1993, Ariane	Store-and-Forward communications, Earth Imaging camera, Cosmic radiation experiment, Star sensor and Transputer experiment, Digital signal processing experiment, Technology transfer for PoSAT Consortium, Portugal
Cerise, 1994, Ariane	Classified payload for Alcatel, France

Surrey Satellite Technology Limited

In order to provide the University with an efficient means to interact with the commercial and industrial world outside the University and related institutions, it was decided in 1985 to form a company called Surrey Satellite Technology Limited (SSTL).

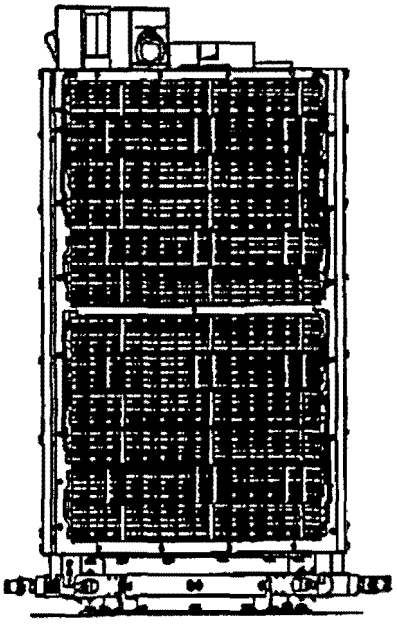
SSTL is a wholly owned University company, which, as a completely independent cost centre, handles all UoSAT external contracts, for technology transfer and manufacturing for external bodies, as well as buying of goods and services for the UoSAT programme.

SSTL forms a clear point of contact for external clients, who can deal directly with the people in charge of the research, development, and manufacture, concerning all matters of technical, contractual, and financial nature, without having to wade through multiple layers of University administration.

Projects executed through SSTL include not only the satellites, but also training contracts for foreign engineers, as well as ground stations for CNES, Korea, Portugal and others.

This Company has seen a remarkable growth since its formation, the surplus income having been used to fund research and development, as well as contributing 1 million pounds to the building cost for the new Centre for Satellite Engineering Research (CSER) which was completed earlier this year.

SSTL now funds a major part of the personnel at UoSAT, either directly or by funding University research posts.



UoSAT-5, pre-launch configuration

Centre for Satellite Engineering Research

The University formed a multi-disciplinary research group in 1991 called the Centre for Satellite Engineering Research (CSER), to capitalise on the wealth of space-related experience available within the various departments.

The main groups within CSER are the following:

- Spacecraft Engineering (UoSAT)

  Power systems, Payloads, Spacecraft mechanics, Attitude determination and control systems, On-board data handling, Communication systems

- Satellite Communications

  Multi-service satellite access protocols, On-board processing, Mobile satellite systems, Low bit rate encoding, digital modulation, propagation study

- Space Robotics & CAD-CAM

  Manufacture of space components, Robot laser tracking, Dynamic metrology

- Space Structures and Materials

  Design and analysis of large deployable structures, Composite materials, protective coatings, Thermal vacuum tests of models

- Education and Training

  PhD research degrees,
  MSc degree in satellite Communications Engineering
  Short training courses,
  Participation in Government education programmes
  Annual IEE summer school,
  Annual AMSAT small satellite colloquium

- Industrial Interface

  SSTL

A Typical Spacecraft Research Programme

In 1989 the Korea Advanced Institute of Science and Technology (KAIST) initiated a four year project, which was to provide Korea with a basis for an autonomous space industry.

The direct aims of the programme were to build and launch a Korean satellite with Surrey, and to gain the experience needed to build a second spacecraft by themselves in Korea.

The KITSAT Satellite

A programme to accomplish those aims was devised to include the following:

- Academic training
- Engineering experience
- Groundstation in Korea
- Satellite design, build, and launch
- Technology transfer

The programme comprised the following year by year activities:

Year 1: A team of Korean engineers to come to Surrey and study for an MSc by Research degree.

The MSc by research involves 30 weeks of 1 day of lectures and four days of work in a relevant field each. The four days were spent at UoSAT, studying various aspects of spacecraft engineering.

Year 2: The first team to assist with the construction of the UoSAT-F (in orbit UoSAT-5)

The five engineers were all assigned a major topic of the spacecraft to study, under the guidance of the respective UoSAT engineer, some assuming spacecraft module responsibility.

A second group to come and study for an MSc by research degree, spending a substantial amount of their time working with UoSAT.

Where the original group specialised on major spacecraft bus systems, as Power, Mechanics, RF systems and Computers, this second group focused attention on experiments and sensors, as the Camera, Radiation experiments, Digital Signal Processing, Attitude sensors etcetera.

Two Koreans assisted the UoSAT-F launch campaign in Kourou.

Year 3: The first two groups to construct KITSAT-A, the first Korean satellite, under the guidance of SSTL/UoSAT engineers.

As a second satellite, S80/T, was constructed by UoSAT/SSTL at the same time, a number of similar systems were built in parallel, with the UoSAT engineer supervising both systems.

A third group of Korean engineers to come and study for an MSc degree, and assist with KITSAT-A.

The third group was smaller, and mainly observed the construction.

The construction of a satellite ground station in Korea, by UoSAT/SSTL

A new ground station was developed, built and supplied to KAIST, and installed in their Taejon facility, under supervision of an SSTL engineer. This ground station enables full control of the KITSAT spacecraft, and it is also compatible with previous amateur spacecraft.

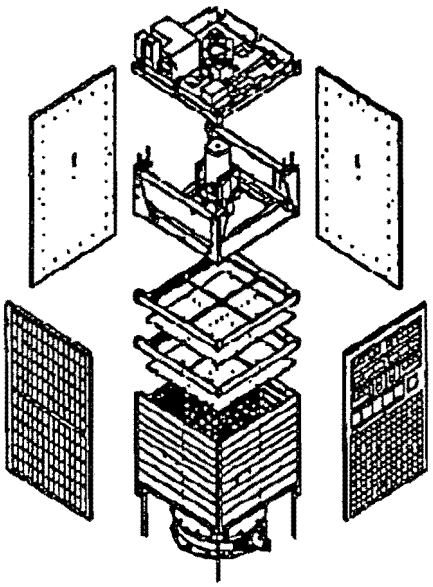
Launch of KITSAT-A (KITSAT-1 in orbit)

The satellite was launched from Kourou, South America, in August 1992, the launch campaign having been performed by a mixed Korean-SSTL/UoSAT team.

Year 4: All Korean engineers to return to Korea, to construct KITSAT-B, using parts manufactured and procured via SSTL, and adding some of their own experiments.

Launch of KITSAT-B (KITSAT-2 in orbit) which is scheduled for 28 September 1993.

The Korean engineers were fully integrated into the SSTL/UoSAT team, which enabled efficient management and exchange of information.



UoSAT-5 exploded view

A similar programme to KITSAT, albeit shorter in duration, has been going on with a consortium of Portuguese companies, resulting in a ground station having been installed in Portugal, and a Portuguese satellite, PoSAT-1 being ready for launch in Kourou, French Guyana.

This will be the first satellite for Portugal, and, using the satellite as a focal point with the experience received by the group of engineers whilst at Surrey, the government hopes to initiate a national programme of space and space related research.

Commercial Opportunities, S80/T

In 1991, the French space agency CNES (Centre Nationale d'Etudes Spatiale) decided to perform a quick response study into the possibilities of using low Earth orbit satellites for communication purposes. This as a precursor to a constellation of satellites called S80.

To confirm all the parameters for this constellation, as links budgets, expected noise and interference and the like, they decided to commission a satellite which would measure those parameters. This satellite was named S80/T, T for Test.

The time available between initiation and launch of this satellite was less than one year, so it was decided to go with a company which had experience with these very short time scale missions.

MATRA, as main contractor for this project, selected SSTL for the spacecraft bus, with the payload electronics being manufactured in France.

SSTL provided drawings for the electrical and mechanical interfaces for the payload to Matra, which were used by other sub-contractors to manufacture the flight hardware.

The microsatellite platform needed only a few modifications to support the specific payload requirements. The battery voltage was raised by adding one cell , and a special high power switch was added. Otherwise no major modifications were needed, demonstrating the versatility of the bus.

All integration and tests of the platform with the payload were performed at SSTL premises, which made it possible to achieve the very tight time scales.

SSTL provided equipment for the Station Sol Utilisour (SSU), the transportable Earth user station. This station is being used in various location around the globe to perform measurements using the satellite.

The day to day operations of the satellite are controlled by SSTL, using the Surrey groundstation.

PoSAT-1, the first Portuguese satellite

Future Missions

The development of UoSAT-based microsatellites is far from over, and every satellite launched by UoSAT/SSTL has included substantial improvements over the previous.

For future missions the expectations are that we will be able to provide higher data rates, more power, and greater payload mass.

For example: one mission currently under construction already provides improvements in these fields, 15 kg payload, 28 Watt orbit average power, and 38.4 kilobit per second

SSTL is also developing a 200 kg Minisatellite for launch in 1995. This minisatellite will provide a greatly increased capability, up to 100 kg payload mass, and 100 Watt electrical power.

Conclusions

SSTL and the UoSAT Spacecraft Engineering Research Unit at the University of Surrey have designed, built, launched and operated 7 microsatellites, supporting a wide variety of experiments. These satellites all have in common: low cost; rapid response, and lifetime up to 9 years in orbit.

Microsatellites are a logical addition to the large satellites in use by most agencies and countries, by allowing a host of possible projects, for which the cost of a traditional satellite, both in terms of cost and organisational effort, would be prohibitive.

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